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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Signed Stephen Hordley

Dated 23 February 2005

Patents Form 1/77

Patents Act 1977
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1/77

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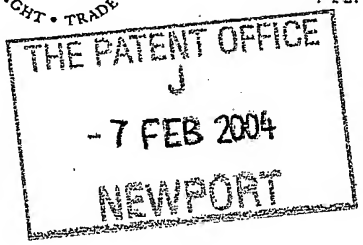
P01/7700 0.00-0402743.9 NONE



Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

616GB

2. Patent application number
(The Patent Office will fill in this part)

0402743.9

7 FEB 2004

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Renishaw plc
New Mills
Wotton-under-Edge
Gloucestershire, GL12 8JR

Patents ADP number *(if you know it)*

2691002

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Method Of Manufacturing A Dental Part

5. Name of your agent *(if you have one)*

M J Fowler et al

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Renishaw plc, Patent Department
New Mills
Wotton-under-Edge
Gloucestershire
GL12 8JR

Patents ADP number *(if you know it)*

2691007

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
–	–	–

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*
–	–

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	8
Claim *(s)*	0
Abstract	0
Drawing *(s)*	2 + 2

10. If you are also filing any of the following, state how many against each item.

Priority documents	0
Translations of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
Request for preliminary examination and search *(Patents Form 9/77)*	0
Request for substantive examination *(Patents Form 10/77)*	0
Any other documents *(please specify)*	0

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 06.02.2004

AGENT FOR THE APPLICANT

12. Name and daytime telephone number of person to contact in the United Kingdom: A Iles 01453 524524

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

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d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

METHOD OF MANUFACTURING A DENTAL PART

This invention relates to a method of manufacturing a dental part and in particular replacement teeth and bridges.

It is known to produce a coping (replacement shell) for a tooth by taking an impression of a jaw and from this, making a positive cast of the tooth. This can be digitised, and a coping machined to size and shape from a block of ceramic however, such ceramic blocks are difficult to machine so, usually a shell is formed (by a pressing or moulding or casting technique) over the cast in a green state and sintered. Finally an enamel coating is added. When the ceramic shell is sintered, it shrinks and this can lead to a mis-match between the tooth and shell.

It is known to make a bridge or a coping by taking an impression of a jaw and from this producing a cast of the relevant part of the jaw. Next, a wax pattern is produced which, for a bridge, consists of a replacement wax replica tooth or teeth between the supporting teeth, wax copings over the supporting teeth and connecting portions of wax between the teeth. For a coping, the wax pattern consists of a wax shell for the tooth which is being repaired. The wax pattern is used as the pattern for the investment casting of a metal bridge frame or coping which is subsequently covered with enamel to produce the final bridge or coping.

According to a first aspect the invention comprises a method of manufacturing a dental part comprising:

producing a near net shape version of the part;

digitising the near net shape version;

comparing the digitised near net shape to an ideal shape for the dental part; and

machining the near net shape version to produce the ideal shape.

A second aspect of the invention comprises a method of manufacturing a coping comprising:

producing a near net shape version of the coping;

digitising the near net shape version;

comparing the digitised near net shape of the coping to an ideal shape for the coping; and

machining at least the inner surface of the near net shape version of the coping to produce an ideal shape.

A third aspect of the invention comprises a method of manufacturing a bridge comprising:

producing a near net shape version of supporting copings as a portion of a bridge structure;

digitising the near net shape version;

comparing the digitised near net shape to an ideal shape for the bridge; and

machining at least the inner surface of the near net shape version of the copings to produce an ideal shape.

It is preferred that the ideal shape of the dental part, coping or bridge is determined by digitising the shape of the dental part, coping or bridge respectively.

The invention will now be described by example and with reference to the accompanying drawings, of which:

Figs 1a,b and c show schematically the production of a coping according to the invention; and

Figs 2a,b and c show schematically stages in the production of a bridge according to the invention.

Fig 1a shows a cast of a tooth form 10 housed within a mould 12. Ceramic material 14 is provided between the cast of the tooth form 10 and a press 16 which bears down on the ceramic material 14 towards the cast 10.

The press 16 is used to compact ceramic material 14 against the cast of the tooth form 10 so the ceramic material 14 takes the shape of the outer surface of the cast of the tooth 10.

When a flat press is used (as shown in Fig 1a) only the inner surface of the coping is formed to near net shape as the inner surface of the coping replicates the outer surface of the cast of the tooth form 10. In this case, in order to produce an outer surface, the compressed ceramic is machined when in a green state to produce a green state coping 18 (see Fig 1b).

Alternatively, the press may have a shaped surface for example it could be formed as one of a standard set of tooth shapes which are selected depending on which type of tooth is required, the age of the patient etc. In this case both the inner and outer surface of the coping is moulded into shape and little or no machining of the green ceramic is required to produce a green state coping 18 (see Fig 1b).

Once the green state coping 18 has been formed it is sintered and during this process the ceramic material

will shrink.

Alternatively, the coping is made from metal and is made using investment casting. In this case, a wax (or other suitable material) replica of a coping is made using the cast of the tooth form. The wax replica is dipped in slip to produce a ceramic mould of the coping. The wax is removed and the mould filled with molten metal which solidifies to form a metal coping. As with a ceramic coping, the metal coping is subject to shrinkage as it solidifies.

A solution to the shrinkage of both ceramic and metal copings is to produce an oversized coping. However, there are problems with this, for example, the cast of the tooth must be made oversized. Also, the shrinkage of the material used needs to be consistent both within a single coping and across material batches.

If the shrinkage is not taken into account during the manufacturing process, and the resultant coping 200 is replaced over the cast of the tooth form 100, instead of fitting against the outer surface of the cast of the tooth form, the coping will be slightly undersized (Fig 1c). In this example the effect has been exaggerated. In order to enable more accurate positioning of the coping 200 onto the cast of the tooth form 100 and thus also the tooth on which the coping is destined to sit without having to resort to the production of oversized parts, the inner surface 300 of the coping 200 is machined until it replicates the outer surface of the cast of the tooth form 100 accurately.

One way to establish where to machine the inner surface

300 for accurate replication is to compare the contours of the inner surface 300 with those of the cast of the tooth form 100 and machine away any discrepancies. Traditionally, the cast of the tooth form 100 is a plaster cast which has been produced using an impression of the actual tooth which is being repaired. The outer surface of the cast is digitised as is the inner surface 300 of the ceramic coating 200 and the resultant digitised forms are compared to establish where there are discrepancies between the two surfaces.

The discrepancies are mitigated by machining the inner surface 300 of the coping 200. This could be carried out as a manual process but it is preferred that it is mechanised whereby a cutting program is produced to remove the excess material from the inner surface 300.

Figs 2a,b and c show stages in the production of a bridge. The bridge 50 comprises three parts, the bridge supports 50a,50c which are disposed one at each end of the bridge and the pontic 50b which is the replacement tooth or teeth which are to be provided by the bridge. In this example, only one tooth is being replaced. In order to make the bridge, a plaster model 52 of the relevant section of a patients jaw is produced. The pontic 50b is made by building-up a wax model 54 of a tooth lying between the supporting teeth 50a,50c. To complete the bridge, a thin layer of wax 56a,56b which connects to the wax model 54 is added to the surface of supporting teeth 50a,50b. This layer of wax 56a,56b represents a coping which will seat, in the patient's mouth, on each supporting tooth, with the pontic spanning the gap.

The wax model 54,56a,56b of the bridge is the pattern for an investment casting process. The wax model is removed from the plaster cast and dipped in slip producing a ceramic mould. The wax is removed from the ceramic mould by heating and draining the liquid wax out. Finally the ceramic mould is filled with molten metal to produce a metallic bridge 58 (Fig 2b). The metallic bridge 58 is coated in enamel to produce the final shape and colour of the teeth.

As with coping production, the metal moulding of the bridge can be subject to thermal shrinkage causing problems with fitting the bridge to the patient. As the length of the bridge is at least three times that of a coping, any shrinkage is magnified over that length (Fig 2c).

In order to alleviate the effects of shrinkage particularly in a bridge but also when a coping is being manufactured, the coping or bridge is made slightly thicker than required which enables machining of the inner surface of the coping(s) in order to provide a good fit with the cast of the coping or bridge.

In the case of a single coping one can merely compare the inner profile of the surface 300 with digitised data of the cast of the tooth form 100.

When a metallic bridge 58 is involved a reference feature 60 is provided on the plaster cast 52 of the bridge 50. This reference feature would have to be located somewhere on the surface where wax is added and used to make the metallic bridge 58. It is preferred

that such a reference is not so close to the edge of the bridge so as to possibly induce a failure or weakness there. The reference feature may be a protrusion or a recess in fact, any discontinuity in the surface profile of the plaster cast which is large enough to be identified when the cast is digitised is applicable.

The reference feature is used to marry up digitised data of the supporting teeth 50a,50b of the plaster cast 52 with that of the inner surfaces of the supporting copings 56a,56b respectively. Either the whole bridge may be digitised or, a reference feature can be provided with respect to each coping which are digitised separately. The digitised data of the cast and inner coping surfaces are compared, any discrepancies identified, and a machining step carried out to remove the discrepancies.

As an alternative to producing a metallic bridge structure, a ceramic bridge may be produced. In this example, the plaster cast 52 digitised. Computer software is used to produce a virtual wax-up of the pontic and supporting coping. A green ceramic bridge is machined to size and shape from a pressed block. The machined green ceramic bridge is sintered to produce the ceramic bridge. The inner surfaces of the supporting copings are digitised and compared to the plaster cast digitised data. Any discrepancies are machined away. As with the metallic bridge, reference points may be provided in order to assist is matching the two data sets. The ceramic bridge is coated with enamel to produce the final bridge.

Although the bridge described in the example has a three part structure, bridges where two pontics are produced may also be made according to the invention.

The surfaces may be digitised by any known means. One way is to scan the surfaces with a probe. The probe may be a contact probe or a non-contact (for example, a laser) probe.

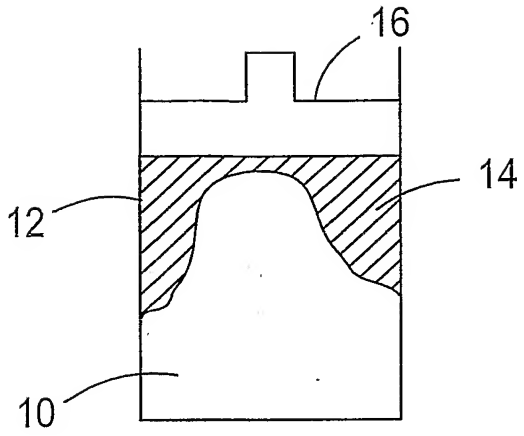

Fig 1a

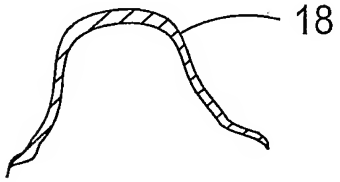

Fig. 1b

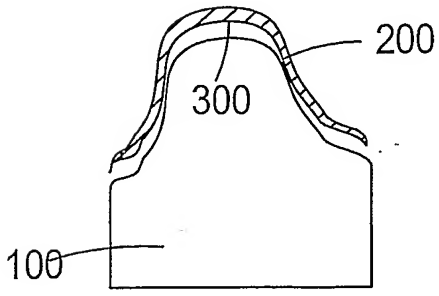

Fig.1c

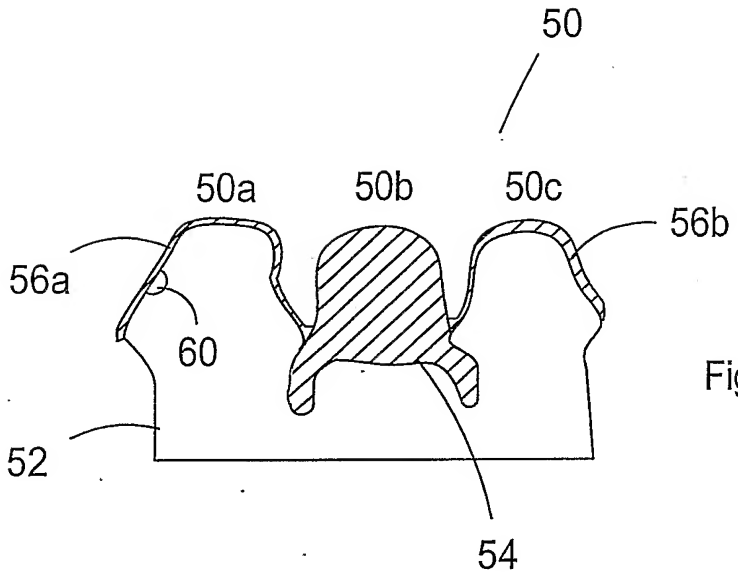

Fig 2a

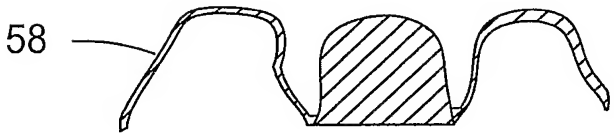

Fig. 2b

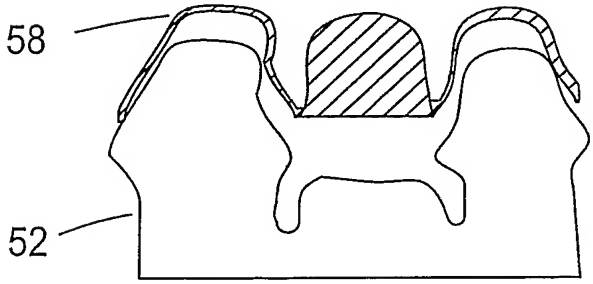

Fig.2c